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Working Paper

TACTICAL MANEUVER SIMULATION SYSTEM (TACMASS)

MANPRINT EVALUATION

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Tactical Maneuver Simulation System MANPRINT Evaluation

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FOREWORD

The TACMASS Concept Evaluation Program was conducted in Friedberg, West Germany, with soldier and facilities support provided by the 3rd Brigade, 3rd Armor Division. The evaluation was conducted by TRADOC Combined Arms Test Activity (TCATA), Battlefield Automation Test Directorate. The Test Officer was MAJ H. Schweppe (AV 738-1209). While ARI (Fort Hood Field Unit) was only requested to evaluate the issues of human factors support of training, system safety, and display visual fidelity, this researcher (author) expanded data collection efforts to incorporate all major MANPRINT concerns allowable within the confines of the evaluation environment. This report represents a comprehensive summary of findings based on several data collection instruments and techniques. As a summary, only the more viable and significant findings are reported.

Appreciation is expressed to ARI Fort Knox Field Unit for their appreciable consultation efforts in developing and clarifying data requirements for a MANPRINT evaluation of a simulation system. MANPRINT efforts with TACMASS on site in West Germany were significantly supported and enhanced by the cooperative team approach exhibited by TCATA test team personnel. This report, in its original form, was officially transmitted to TCATA on 18 Sep 87.

Tactical Maneuver Simulation System (TACMASS) MANPRINT Evaluation

PURPOSE

The purpose of this Concept Evaluation Program (CEP) was to evaluate the use of the Tactical Maneuver Simulation System (TACMASS) to conduct tactical maneuver and command and control training at company and platoon level. Test results will be used to assess requirements for company and platoon training simulations. The test organization was TRADOC Combined Arms Test Activity (TCATA).

MANPRINT requirements for a system are designed to maximize system effectiveness through concern for the interface between equipment design and soldier capabilities. MANPRINT concerns, as dictated by the Test Design Plan (TDP), were addressed through three issues: a) Is the visual presentation of the system effective, b) Do the human factor aspects of the system support optimal training, and c) Is the system safe to operate and maintain? These issues, along with ancillary issues involving personnel and manpower, were investigated by the Army Research Institute (ARI), Fort Hood Field Unit.

BACKGROUND

ARI was requested by TCATA to participate in the TACMASS Working Group Meeting of 24-25 Jun 86, during which a revision of the TACMASS Resume Sheet for the CEP was discussed, with particular concern for restating issues and test design. Revised TACMASS issues, as appropriate to MANPRINT, and supporting draft data requirements (DRs) were provided TCATA 27 Aug 86. Review of the Test Design Plan (TDP) for TACMASS (CEP 197) was completed, with comments, on 26 Jan 87, and the TDP was approved 12 Feb 87. ARI responsibility included the design of instruments and procedures for collecting biographic, observational, attitudinal, and performance data and the analysis and report thereof. ARI provided TCATA with a draft biographical questionnaire to capture data for use in matching groups and a draft observational checklist to obtain objective MANPRINT data in Mar 87. A list of quantifiable potential performance measures relevant to an armor company ARTEP was also provided TCATA in Mar 87. ARI requested and received (25-26 Mar 87) technical assistance from the Fort Knox Field Unit, based on their experience with SIMNET, in clarifying data needs and collection to support evaluation of MANPRINT concerns. ARI provided TCATA a draft instrument to assess training experiences, projected transfer, and system operation in May 87. The provision of draft, as opposed to finalized, DRs and associated data collection instruments was necessitated by the lack of opportunity to view TACMASS prior to testing.

ARI and Subject Matter Expert (SME) personnel arrived on site (3rd Brigade, 3rd Armor Division, Friedberg, FRG) 4 Jun 87 and underwent TACMASS training and familiarization 5-7 Jun. This experience, along with that of a pilot study conducted 9-12 Jun, stimulated the redesign of some data collection instruments and the design of several new forms (Operator Training Checklist, Tutorial Evaluation). Observational data collection began 4 Jun 87 and continued through approximately 10 Jul 87. Formal TACMASS training data collection began 15 Jun and continued through 1 Jul 87. ARI analysis and reporting began 8 Jun

and continued on site through 13 Jul, with efforts continuing at Fort Hood, TX from 29 Jul through approximately 15 Sep 87. ARI did not participate in ARTEP Evaluator training, ARTEP data collection, or post-ARTEP data collection.

SYSTEM DESCRIPTION

The Tactical Maneuver Simulation System (TACMASS) is a multi-station, interactive, real time, computer training device which utilizes three control (threat, fire support, trainer) stations and, as presently configured, 18 vehicular stations (4 platoons of 4 vehicles each, CO, XO). Emphasis is placed, by design, on tactical training inclusive of defensive and offensive maneuvering, engaging, and command and control, and the system can play OPFOR (controlled by the Threat station) or force-on-force. TACMASS allows the video recording of all operations along with computer entry of Controller-Trainer comments and has playback After Action Review (AAR) capabilities. As presently configured, each vehicle station provides two terminals (screen and controls), one for a driver position and another for a commander/gunner position. The Platoon Leader (PL), CO, and XO stations contain a third terminal (screen and controls) in each. This configuration allows for simultaneous training of 6 officers and 36 enlisted soldiers. The TACMASS operates on modifiable parameter models of acquisition, shooting, and vulnerability, and incorporates digitized terrain (6.25m resolution with 12.8 km by 12.8 km memory), color displays, and programed scenarios. The system operates in three modes: a) PRE, which allows reconnaissance of terrain, to include cover and concealment, and fields of fire; b) SIM, which allows vehicular movement, shooting, and the conduct of battles; and c) an evaluation mode during which there is a playback of the entire battle on a large screen monitor to support AAR. During the PRE and SIM modes, audio communications networks (within vehicle, within platoon, within company, between company and Controllers) are functional and traffic is recorded for playback during the AAR. A Programmed Introduction for Familiarization (tutorial) is available. Training is required in order to operate a vehicle or controller station.

The TACMASS is configured as indicated in Figure 1, with all stations as members of a Local Area Network (LAN). The CO, XO, and PL stations (player stations) are configured as standard vehicle stations with the addition of a third position (screen and vehicle commander/gunner controls). The Main, Controller-Trainer, Fire Support, and Threat stations are discrete and uniquely configured.

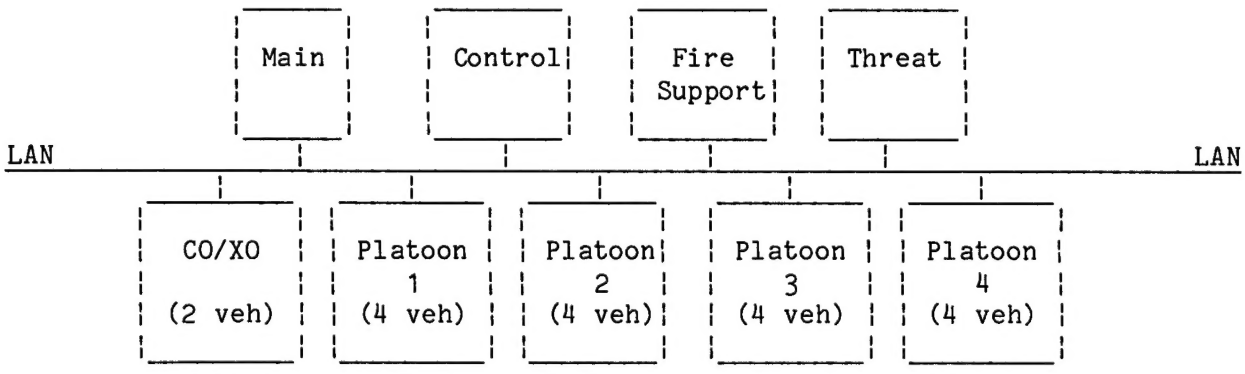

Figure 1. Configuration of the TACMASS as a local area network.

TACMASS player stations, representing 18 vehicles, are partitioned cubicles housing a driver (D) and a track commander/gunner (TC) position. The CO, XO, and PL stations add an additional TC position with an override switch to allow assumption of gunnery functions and configuration (mounted or dismounted). Each vehicle station has a table and two (or three) chairs, two (or three) color monitors, one driver's control panel, one (or two) TC/gunner's control panel, and an interconnecting station control module. Each platoon, composed of four vehicles, as shown in Figure 2, and the CO and XO stations (2 vehicles) are operated through separate rack-mounted computers, as is the Threat station. A single rack-mounted computer at the Main station handles the Fire Support and Controller-Trainer stations and is interactive with all other computers. Industrieanlagen Betriebsgesellschaft mbH (IABG), the West German developer and manufacturer of TACMASS, indicated the need for constant environmental control to support equipment operation.

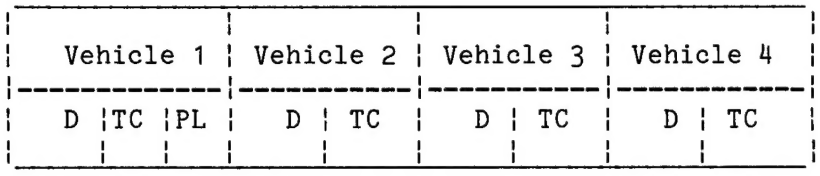

Figure 2. Configuration of the TACMASS platoon stations.

TRAINING DESCRIPTION

TACMASS training was conducted in a section of a warehouse converted to accommodate system and personnel needs: central heating and air conditioning, florescent lighting, linoleum flooring, acoustical ceiling, station partitioning, and enhanced electrical supply. Each player company was trained as a unit: typically 18 drivers, 18 vehicle commanders/gunners, 4 platoon leaders, 1 company commander, and 1 executive officer. Soldiers (officers and enlisted) received system operation training in a single training period of approximately four hours. This training, conducted on site by IABG, generally reflected the schedule recorded in Table 1.

Table 1
TACMASS System Operation Training for Soldiers

Time (min)	Activity/Topic
10	Introduction of test and personnel
50	Overview and briefing - system and station operation
45	Exercise 1 - familiarity with controls, movement, terrain, symbology, and limitations
15	Break
20	Briefing - visibility, acquisition, engaging, kills, AAR
25	Exercise 2
15	After Action Review
10	Break
20	Briefing - scenario, recon, formation moves, contact
40	Exercise 3
20	After Action Review

hese times constitute averages and varied appreciably among the four companies trained. The average time a company spent at the training site (4.4 hours) included 10 to 15 minutes to complete a training evaluation checklist and an average of 10 minutes of system down time. System operation training was followed by four (one per day) tactical training periods of aproximately five hours each. This tactical training was driven by ARTEP-related scenarios designed by SMEs.

Controllers (Threat, Fire Support, Trainer) were trained independently of player units. Their training, conducted on site by IABG, was intended to allow them to operate specific stations, though familiarization with all stations was facilitated. Each controller station was discrete and unique in configuration, workload, and operational tasks. Controller training generally reflected the schedule recorded in Table 2.

Table 2
TACMASS System Operation Training for Controllers

Time (min)	Activity/Topic
10	Introduction of test
20	Overview - system characteristics, capabilities, components
10	Vehicle station demonstration
10	Controller/Trainer station demonstration
10	Fire Support station demonstration
10	Threat station demonstration
20	Break
30	Exercise 1 - operation of vehicle station
35	Exercise 2 - operation of assigned controller station
10	After Action Review
20	Exercise 3 - operation of assigned station
15	After Action Review
10	General questions
30	Exercise 4 - operation of asigned station
15	After Action Review

These times constitute averages of the two groups of controllers trained. The average time spent at the training site (4.4 hours) included 10 minutes to complete a training evaluation checklist and periodic "informal" breaks. Of note, Exercise 4 time was 15 minutes for one group and, at the request of the Threat station trainee for additional time, 45 minutes for the other group.

METHODOLOGY

The TACMASS CEP employed a matched-groups research design in which the four companies to receive TACMASS training were matched with four companies that were not to receive this training. Suggestions for matching variables, to include ASVAB scores (GT, MC), were provided by ARI to TCATA who affected the actual matching. All companies (8) were scheduled for ARTEPs during the same training window. TCATA assumed responsibility for collection and evaluation of ARTEP performance data on all companies to facilitate comparison of TACMASS-trained units with those not so-trained.

The on site collection of MANPRINT data utilized multiple sources and techniques. Both objective and evaluative data were collected from TACMASS users (players) through interviews, checklists, observations, and questionnaires. These data focused on training (system and tactical) efficacy, transfer value, and system evaluation. Objective data were collected from Test Team members and SMEs through checklists, interviews, and roundtable discussions. These data primarily focused on system assessment and evaluation, tutorial evaluation, task analyses, personnel observations, and user-system interface problem identification. User performance data, such as time to complete scenarios and ARTEP STX (situational training exercise) critical task success, were recorded on video tape for use in AARs. Critical task completion assessments were also evaluated on checklists used by observing SMEs. Additional performance data were obtained during player unit follow-on ARTEPs. All performance data were collected, analyzed, and reported by TCATA and were primarily focused on system capabilities, training efficacy, and training transfer.

In addition to observations and measurements made by ARI and interviews conducted by ARI, a number of ARI-designed instruments were used in data collection. The matrix presented in Table 3 provides identification of and summary information about these techniques and instruments.

The Biographical Data Questionnaire, as modified by TCATA to accommodate additional concerns and variables for accomplishing matching, was administered and used by TCATA. SMEs and Test Team members were informally debriefed during their own system training, the pilot test, and player system and tactical training they monitored. These efforts, the results of which were roundtabled and recorded in the Observational Comments Report, sought information from the broadest perspective possible on system or training deficiencies and/or possible improvements. The Tutorial Evaluation (DC Form 1-39) and Observational Checklist (DC Form 2-17) were provided to SMEs and Test Team members toward the end of soldier TACMASS tactical training exercises, and completion was self-paced. The Programmed Introduction for Familiarization (PIF) Evaluation was conducted throughout the TACMASS training period as time and circumstances permitted access to a computer terminal. The Operator Training Checklist (DC Form 1-41) was administered by ARI to each company of soldiers upon their completion of TACMASS system training and upon their completion of scenario-structured tactical training. This administration schedule allowed opportunities to compare selected aspects of training and perceptions of TACMASS; the second administration allowed for a "meaningfulness" or contextual factor, as system training was focused in tactical training exercises. The Assessment of TACMASS Training (DC Form 2-18) instrument was administered by TCATA to companies when they completed all TACMASS training (system and tactical). Additional data, primarily of human factors content such as physical measurements of controls, were collected by ARI throughout conduct of the TACMASS CEP.

Table 3
ARI Data Collection Instrument Matrix

Instrument	Type	Content	Items	Target
Biographical Data Questionnaire	Objective questionnaire	Personnel data for matching groups	31	Brigade soldiers
Observational Checklist (DC Form 2-17)	Objective checklist, task analysis	Training, Human Factors, Personnel, Manpower, Safety, Health Hazards	110	SMEs, Test Team
Tutorial Evaluation (DC Form 1-39)	Subjective ratings	Language, Expression, Content	4 per station	SMEs, Test Team
Operator Training Checklist (DC Form 1-41)	Subjective evaluations	Training, Transfer	35	Soldiers
Assessment of TACMASS Training (DC Form 2-18)	Subjective ratings	Training, Health Hazards, Human Factors	85	Soldiers
Observational Comments Report	Interviews, Observations	Training, Human Factors, Safety	46	SMEs, Test Team
Programmed Introduction for Familiarization Evaluation	Objective assessment	Training	22	ARI

SUMMARY FINDINGS: TACMASS SYSTEM

This section addresses TACMASS as a physical entity, the design, operation, and response requirements of which must optimize the interface with soldier operators. Translated into MANPRINT concerns, these findings reflect on human factors, safety, and health hazard issues and associated data requirements. Information and data were obtained from three major sources or techniques: a) structured data collection forms (Observational Checklist), b) debriefings of evaluators (Observational Comments Report), and c) ARI deliberate human factors assessment. A majority of data points constituted objective observational assessments, to include some physical measurements. Contributors of these data were Subject Matter Experts (AR and INF), both military and civilian Test Team members, and an ARI research psychologist. The report of findings, as follows, concentrates on the most important or influential system deficiencies. More exhaustive and detailed findings have been recorded in the Observational Comments Report and TACMASS Observational Checklist Consensus Report of SMEs and Test Team Members.

OBSERVATION 1.0 There are wide variations within and between TACMASS stations in display screen color and brightness prior to bringing the terrain program on-line. Color discriminability is critical to performance; and hues and saturations, as well as brightness, need to be standardized across all display screens.

RECOMMENDATION 1.1 Calibration of screen colors and brightness should be an essential task of PMCS and performed at least weekly.

OBSERVATION 2.0 Display color codes and topography, while described in station training, are not readily available to operators though they are critical.

RECOMMENDATION 2.1 Color code and topography legends should be posted in each station in ready reference form. A legend for vehicle types, vehicle status, and source of engagement was developed by the Test Team and posted in vehicle stations. This practice should be continued.

OBSERVATION 3.0 Some stations' display screens, dependent upon station location relative to indirect lighting, suffer from glare which degrades visibility of display features. Reducing overhead lighting degraded map reading in some stations.

RECOMMENDATION 3.1 An optimal light level which minimizes glare and supports map and legend reading should be determined, and the physical location of stations relative to light source be considered. Alternatives to this "environmental engineering" include providing an adjustable lamp in each station and/or the use of display screen glare shields.

OBSERVATION 4.0 Display screens are heavy and, hence, difficult to move. Movement is often necessary within a vehicle station to allow the Driver to see the Gunner's view, and vice versa. The necessary effort to accomplish this manipulation could damage equipment, cause accidental adjustment of display controls, and be unsafe for the soldier.

RECOMMENDATION 4.1 Vehicle display screens should be swivel-mounted to allow partial rotation.

OBSERVATION 5.0 After a fire or mobility kill, communication is halted from the TC or Driver position, respectively. This situation is not necessarily realistic and precludes effective command and control.

RECOMMENDATION 5.1 Communications within and between vehicles should not be terminated unless a vehicle is a total kill.

OBSERVATION 6.0 Following a fire kill, a vehicle's commander/gunner controls are dead. This severely reduces visibility and reconnaissance opportunities and the ability to mount or dismount infantry in appropriate vehicles, and is not necessarily realistic.

RECOMMENDATION 6.1 Following the fire kill of a vehicle, the only controls which should be decommissioned are the fire and ammo selection buttons.

OBSERVATION 7.0 When a blue (friendly) force vehicle depletes its fuel or ammunition supply or experiences a kill (mobility or fire), it becomes a lost asset, since no rearm, refuel, or repair capabilities exist. While this situation is not realistic, the disadvantage to blue forces is compounded by the red (OPFOR) capability of regeneration if killed and no limitations on fuel or ammunition.

RECOMMENDATION 7.1 Software programs should be rewritten to accommodate refueling, rearming, and some repair of blue vehicles. A realistic time penalty (no move/no fire) should be imposed on affected vehicles.

OBSERVATION 8.0 While the AAR capabilities of TACMASS offer strong training benefits, the AAR screen and controls configuration detracts from optimal use. The Trainer must often block portions of the screen to view or point something out, thereby reducing soldier visual access/visual angles.

RECOMMENDATION 8.1 Integration of a satelite AAR Trainer station, to include a separate screen, light pen, and marking capability, could significantly enhance the AAR as a teaching tool. Consideration should be given to modifying the Controller/Trainer station to accommodate these changes.

OBSERVATION 9.0 The ability to play mechanized infantry is degraded by the capability to maneuver and fight only the vehicle or the squad. Also, when in the dismounted mode, the vehicle armament is not usable against OPFOR.

RECOMMENDATION 9.1 The addition of an independent Gunner position in each vehicle station for squad manipulations and software adjustments to upgrade M2/113 armament would enhance TACMASS use by mechanized infantry units.

OBSERVATION 10.0 Based on current programing, weapons have no effect on structures such as bridges, buildings, barriers, and obstacles. This condition is not realistic and restricts tactical operations.

RECOMMENDATION 10.1 The cover/concealment and impediment characteristics of structures should be programed to allow alteration if hit by fire.

OBSERVATION 11.0 A major time-consuming task at the Fire Support station is the placement of barriers, further complicated by the need to replicate this task each time the appropriate scenario is played.

RECOMMENDATION 11.1 Equip the Fire Support station with a light pen to facilitate barrier emplacement, modification, or removal.

OBSERVATION 12.0 A major time-consuming task at the Threat station is the plotting of OPFOR movements which uses a mouse to "draw" discrete "tracking" lines for forces to follow. The time and effort involved in this task degrades appropriate and tactically correct use of terrain features and cover and concealment by OPFOR.

RECOMMENDATION 12.1 Equip the Threat station with a light pen for use in affecting tactically real OPFOR maneuvers.

OBSERVATION 13.0 The terrain appreciation intent of the horizontal view mode is jeopardized by the system's inability to provide a visual perspective of barriers, depressions/ditches, and impassable terrain. It is not possible to gage the severity of impediments to movement.

RECOMMENDATION 13.1 Impediments which are natural features of digitized terrain should be programmed to have 3-dimensional characteristics.

OBSERVATION 14.0 The identity of a displayed vehicle is limited to color (red or blue) and type (tank or infantry fighting vehicle). Command and control capabilities and realism are degraded by inability to establish the specific identity of a vehicle.

RECOMMENDATION 14.1 In the programing of the TACMASS, each vehicle (blue and red) is identified by number; for blue forces, the programed vehicle number corresponds to station number. These identifying numbers are available to Threat and Controller/Trainer station operators. Since this information is available, program modifications should allow vehicle numbers to be displayed on each vehicle.

OBSERVATION 15.0 Vehicle and dismounted infantry armament includes machine guns which are essentially useless against OPFOR as currently programed.

RECOMMENDATION 15.1 Consideration should be given to programing for OPFOR dismounted infantry capability. However, such a decision should take into account realistic OPFOR use of infantry and the likely appreciable increase in workload on the Threat station.

OBSERVATION 16.0 The system presently allows for sound effects only when a blue force vehicle is being fired upon. There are no sounds to accompany any action, such as moving or firing, by blue force vehicles and this degrades realism.

RECOMMENDATION 16.1 Since sound effect (incoming fire) capabilities already exist in the system, they should be extended to include blue force firing and motor noise.

OBSERVATION 17.0 Barriers, obstacles, and terrain features are essentially without consequence to the movement of OPFOR. This situation allows for unrealistic maneuvering of OPFOR and degrades tactical planning by blue forces.

RECOMMENDATION 17.1 OPFOR maneuvering should be guided by the same (and real) constraints as blue forces face, and OPFOR movement programing should be accordingly adjusted.

OBSERVATION 18.0 All vehicles (OPFOR and blue) are able to drive through trees, wooded areas, heavy vegetation, and steep grades (possibly rocky or precarious) with the only cost that of speed. This is not realistic, since vehicle damage or incapacitation might be expected.

RECOMMENDATION 18.1 The system should be programed to allow for the possibility of a mobility kill to simulate vehicle damage. This could likely be accomplished by altering the vulnerability model.

OBSERVATION 19.0 Symbology for trees and hedges or bushes in the horizontal display mode depicts this vegetation as block-shaped. This situation is unrealistic, though not operationally consequential. However, this degraded realism stimulated a number of specific derogatory comments from soldiers and more general comments demeaning overall TACMASS graphics.

RECOMMENDATION 19.1 Respecting the sophistication of this simulation system, it is reasonable to expect and require improvements in graphics which would lend more realism. In particular, tanks should look like tanks, etc.

OBSERVATION 20.0 It is not possible for an infantry vehicle to mount a squad belonging to another vehicle. This limitation is not realistic in relation to actual field operations including "rescue" missions; it detracts from related command and control training opportunities.

RECOMMENDATION 20.1 The system should be programed to accommodate mounting a squad in a vehicle other than that from which it was dismounted.

OBSERVATION 21.0 Station displays provide information on cursor position using an "E" plus 3-digit number on one line and an "N" plus 3-digit number on the next lower line.

RECOMMENDATION 21.1 The display listing of cursor position should be revised to provide a 6-digit coordinate on a single line. This modification would allow better transfer of map reading and positional reporting skills.

OBSERVATION 22.0 During TACMASS use, IABG allowed rear doors on rack-mounted computers (7) to remain open, reportedly to enhance cooling. This practice exposed electrical hazards.

RECOMMENDATION 22.1 Leaving rack doors open is of doubtful efficacy in dissipating hot air and certainly was a safety hazard. If the rack-mounted fans in each unit were not able to maintain adequate air flow, consideration should be given to design changes such as more powerful fans or different panel arrangements. Only half of each unit's rack space was used by computer components.

OBSERVATION 23.0 There is appreciable lag time, likely related to computer workload at any given time, when changing view modes (horizontal, 800m, 6400m) and between cursor movement and grid coordinate display change. Besides being an annoyance, this situation is potentially consequential when time is important, such as when acquiring a target, identifying and reporting an OPFOR, or maneuvering to avoid enemy detection or fire.

RECOMMENDATION 23.1 The need for rapid target identification, reporting, acquisition, and responsive maneuvering is real; appropriate performance must not be jeopardized by lengthy computer processing times for command and control manipulations. Consideration should be given to system upgrading to reduce process time.

OBSERVATION 24.0 As currently configured, soldiers must bring Combat Vehicle Crew (CVC) helmets to facilitate communications within and between stations. Also, connection of a CVC helmet to the connector on the display module base often required petroleum jelly. Further, soldiers had to be concerned about the safeguarding of their CVC helmets, as this equipment was signed out to them.

RECOMMENDATION 24.1 Headsets for each position in each station should be furnished on site and considered as intricate parts of the TACMASS operational configuration.

OBSERVATION 25.0 The TACMASS presently has separate stations for Controller/Trainer, Fire Support, and Threat, with the latter in a separate cubicle. These controllers must interact extensively in coordinating their efforts.

RECOMMENDATION 25.1 Stations for controllers should be combined in a single and isolated cubicle to enhance communications and operational efficacy.

In addition to the observations and assessments provided by SMEs, Test Team members, and ARI, soldiers using the TACMASS provided a number of comments on the system. These comments were in response to questions on the TACMASS Operator Training Checklist which solicited suggestions for improvement. The administration of this checklist toward the end of TACMASS tactical training exercises yielded 119 usable returns: 20 from officers, 42 from vehicle commander/gunners, and 57 from vehicle drivers. A synopsis of these system-related suggestions for improvement follows.

OBSERVATION 26.0 (station controls) Of 6 comments contributed, 5 suggested needs for improved or more realistic controls.

EVALUATION 26.1 From a human factors perspective, vehicle station controls were not deficient in type, configuration, spacing, size, durability, or labeling. However, vehicle driver controls, and particularly steering, could be made more realistic.

OBSERVATION 27.0 (station displays) Of 26 comments contributed, 18 suggested needs for improved graphics or realism.

EVALUATION 27.1 The quality of display graphics in terms of realism was relatively poor when compared to that available in a typical video game. Particularly deficient graphics include vehicles, dismounted squads, trees and bushes, bridges, and buildings. (See also OBSERVATION 16.0 and 19.0)

OBSERVATION 28.0 (station capabilities and parameters) Of 32 comments contributed, 9 suggested needs for more realistic armament/weapons, 6 suggested the need for target acquisition in the horizontal view mode, 6 suggested providing a horizontal view for drivers, and 7 suggested the elimination of the Driver position.

EVALUATION 28.1 The current Driver's view (800m) is not the most realistic perspective, and the addition of a horizontal view (terrain appreciation) would be beneficial. Also, a horizontal view target acquisition and engagement opportunity for the TC would add reality to these tasks. Although the training value of Drivers' position tasks is likely low compared to that of other positions, and the vehicle Commander/Gunner could fairly readily assimilate Driver tasks, the elimination of Driver positions may significantly degrade command and control training value and eliminate the opportunity for drivers to gain an understanding and appreciation of tactical maneuvering. (See also OBSERVATION 5.0, 9.0, and 15.0)

OBSERVATION 29.0 (system capabilities and parameters) Of 44 comments contributed, 9 suggested the need to provide for vehicle identity, 3 suggested needs for OPFOR movement constraints similar to blue forces, 3 suggested a need to be able to transfer troops and ammunition between vehicles, and 6 suggested the need to reduce system response time. Likely in response to a number of system "glitches" evidenced during the TACMASS CEP, 9 comments on eliminating program bugs were recorded.

EVALUATION 29.1 The comments are consistent with deficiencies noted by evaluators and recommendations for improvements. (See OBSERVATION 7.0, 14.0, 15.0, 17.0, 20.0, and 23.0)

The TACMASS Obserational Checklist completed by SMEs and Test Team members included human factors and safety questions primarily directed at station configuration, the physical nature of controls and displays, and identification of possible safety hazards. The nature of checklist items was guided by appropriate sections of MIL-STD-1472C. A general description, written and pictorial, and an evaluation of the controls and displays within a vehicle station follows, along with identified deficiencies. Figures 3 through 8 depict station position displays, controls, and configurations.

Displays: Color, 10.5" high by 12" wide screen, 2.5" of screen width used for information and status alphanumerics, screen inset 1.5".

Controls, Driver: Console, plastic and metal, 16" wide by 7.5" high by 1.25" deep in front and 2.75" deep in back, joy stick (forward-backward movement) in center of left side, round knob (left-right movement) in center of right side.

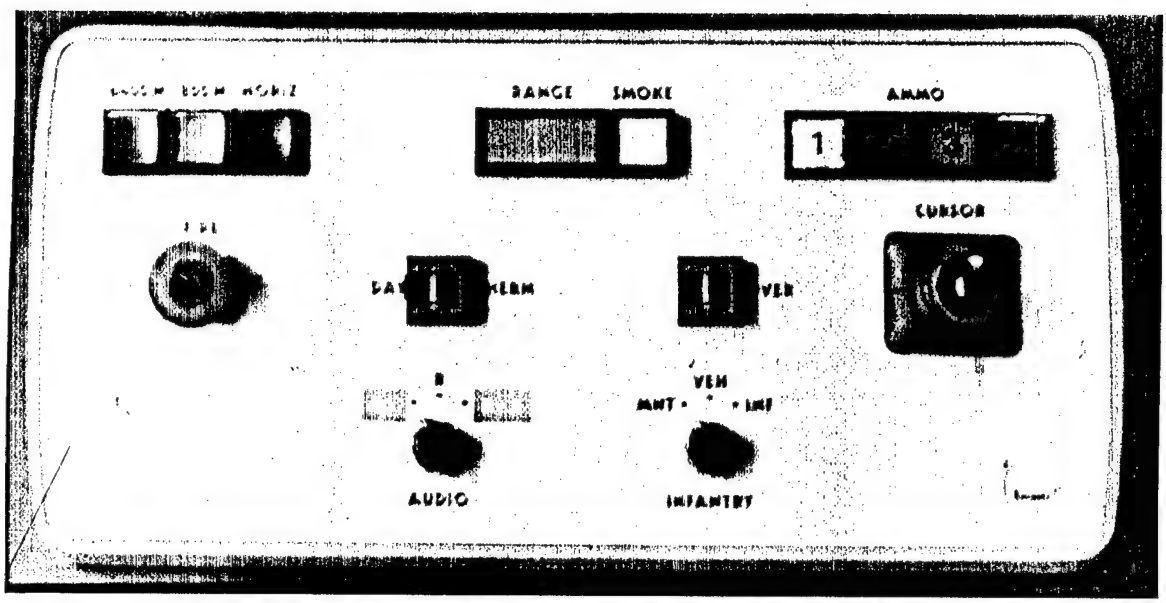

Figure 3. Operator control panel, vehicle station, Commander/Gunner position.

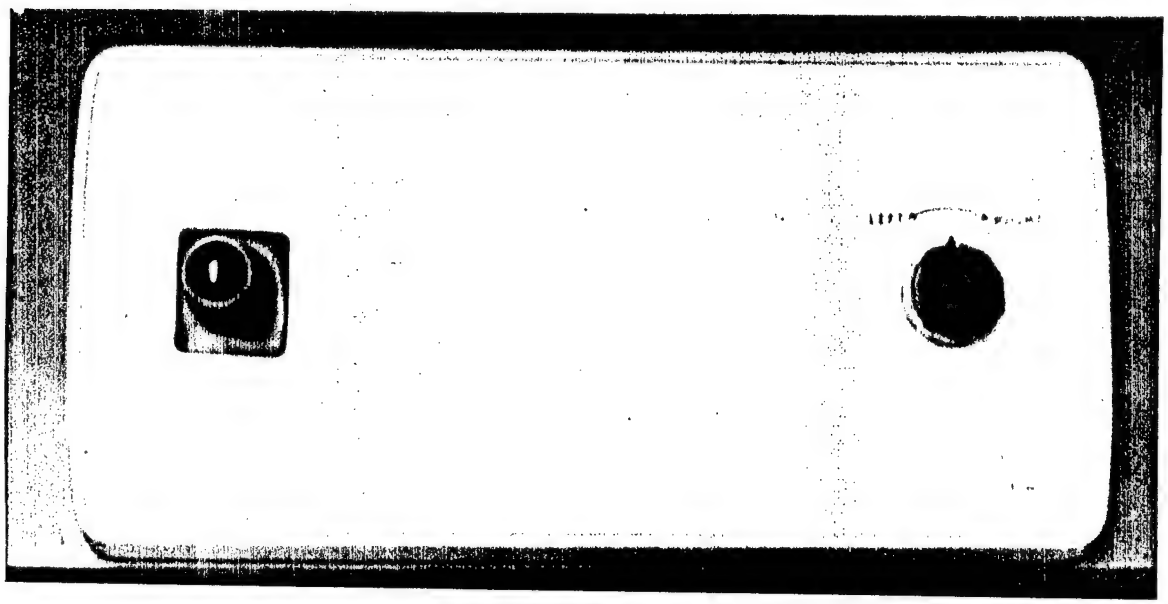

Figure 4. Operator control panel, vehicle station, Driver position

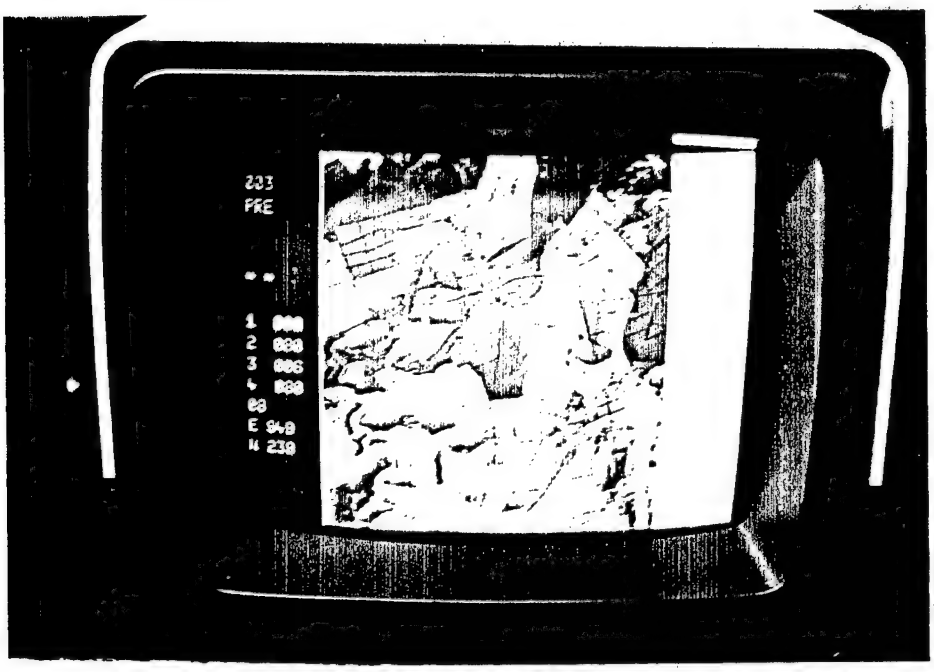

Figure 5. Operator screen, vehicle station, Commander/Gunner position. As pictured, 6400m view mode, vehicle ID, vehicle status, ammunition supply, and cursor location coordinates.

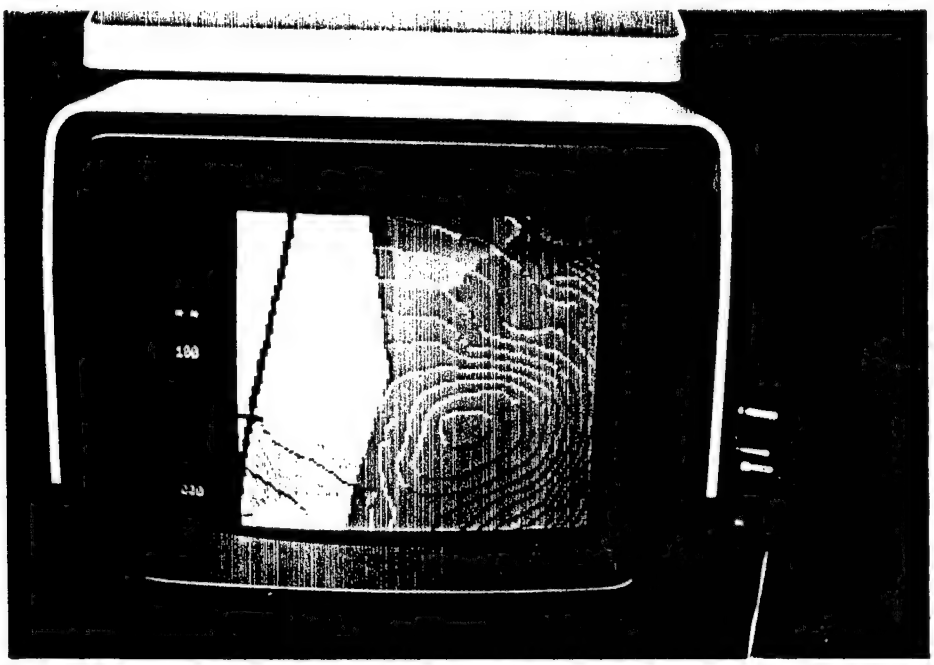

Figure 6. Operator screen, vehicle station, Driver position. As pictured, 800m view mode, vehicle status, fuel supply, and vehicle speed.

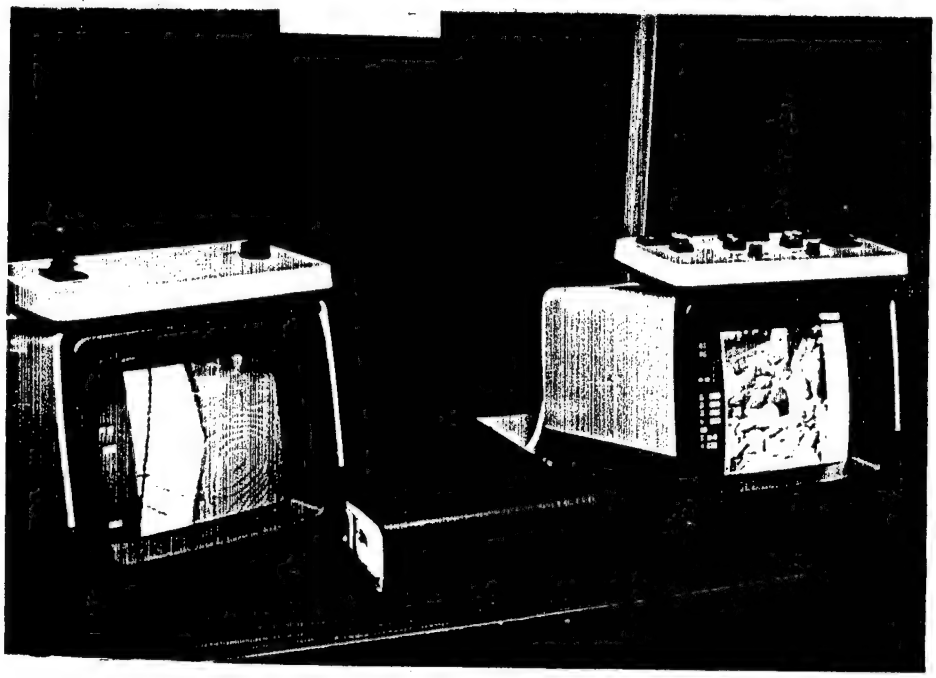

Figure 7. Vehicle station configuration for Driver (left) and Commander/Gunner (right).

Figure 8. Vehicle station configuration with addition of Platoon Leader, XO, or CO position (center).

Controls, Commander/Gunner: Console, plastic and metal, same dimensions as Driver, 3 color-coded push buttons (view mode) top left, 2 color-coded push buttons (range, smoke) top center, 4 color-coded push buttons (ammunition) top right, 1 push button (fire) center left, 2 toggle switches (day/thermal, override) center, joystick (cursor movement) center right, 2 color-coded pointer knobs (audio net, infantry configuration) center bottom.

OBSERVATION 30.0 Vehicle station controls appeared sturdy, well protected, reliable, properly sized, adequately spaced, appropriately clustered, appropriately positioned, well identified (colors) and labeled; good panel symmetry; no exposed connections, no apparent safety hazards.

RECOMMENDATION 30.1 From a human factors perspective, the workload of the Driver's position is low - the Driver has nothing to do unless the vehicle is moving. Consideration should be given to combining Driver controls into a single joystick, appreciably reducing the control console size, and providing the Driver with a horizontal view (terrain appreciation) opportunity. In the absence of supportable training value for this position, consideration should be given to eliminating it by adding a single control for movement to the Commander/Gunner control console. Also, view mode selection push buttons should be modified to "click" when there is sufficient detent to initiate a view change.

OBSERVATION 31.0 Sound levels within communications networks (using CVC helmets) were not adjustable, and some "bleeding over" of nets was reported.

RECOMMENDATION 31.1 Provide a volume control, preferably on existing control consoles, and a squelch control. The ability to control volume is both an operational and safety (hearing) need. (See also RECOMMENDATION 24.1)

OBSERVATION 32.0 Vehicles, both OPFOR and blue force, were able to travel through other vehicles, either alive or killed. Also, use of a killed vehicle as a deterrent to visibility (cover and concealment) appeared to have no effect. (See also OBSERVATION 17.0 and 18.0)

RECOMMENDATION 32.1 Vehicles should be programed to represent the same movement impediment as a barrier. Also, assuming a true line of sight (LOS) situation, and depending on the physical characteristics (length, height) of each vehicle, programing for visibility should allow use of one vehicle as a shield for another.

OBSERVATION 33.0 Several potential safety hazards were reported: exposed cabling and connectors (see OBSERVATION 22.0), exposed female power sockets in station control modules, and station partition legs (inverted "T"). None of these potential hazards were labeled.

RECOMMENDATION 33.1 Power connectors in station control modules should have plastic caps to protect against accidental shock. These connectors are close to reset buttons which are periodically used. All areas of potential electrical shock hazard should be clearly labeled. The hazard of station partition legs, pending more permanent installation, can be reduced in training.

SUMMARY FINDINGS: TACMASS PERSONNEL AND MANPOWER

This section addresses the personnel support requirements for operating and maintaining the TACMASS. Information and data were obtained from two sources: a) TACMASS Observational Checklist, and b) ARI deliberate assessment. The collection of objective data on maintenance and personnel was complicated by a) the large number of IABG personnel involved, b) conduct of maintenance and both hardware and software modifications and repairs while Test Team members were not on site, and c) Test Team members' lack of technical expertise in computer electronics and programing needed to fully understand all repair and modification efforts by IABG. Results of this data collection, in consideration of the preceding reservations, are listed as descriptive findings, some of which have associated recommendations.

OBSERVATION 34.0 A majority of maintenance/repair operations was conducted by factory representatives (IABG) functioning as contractors.

RECOMMENDATION 34.1 Based on observations and information obtained from IABG, the complexity of the computer hardware and software of the TACMASS is sufficient to require IABG system specialists (developers) to perform repairs. Beyond PMCS, consideration should be given to contracting maintenance.

OBSERVATION 35.0 No valid estimate of maintenance workload was available because a majority of repairs and modifications took place unsupervised and outside of test hours.

OBSERVATION 36.0 Known maintenance actions include: a) repair of vehicle control console, screen monitor, hard disc drive, b) replacement of hard disc drive, vehicle control console, and c) adjustment of screen monitors, communication system, vehicle control modules (resets).

OBSERVATION 37.0 No particular qualifications for personnel responsible for providing TACMASS operation training were suggested, assuming the trainer has adequate knowledge of system operation procedures and capabilities and combat arms.

OBSERVATION 38.0 Operation of controller stations required three personnel. MOSs of 35 (MI), 13 (FA), and 11 (INF) or 12 (AR) were identified as most relevant to station manning. These personnel requirements exist during all times the TACMASS is used by a unit. The 35 and 12 MOSs exist as authorized strength in an armor battalion. The 13 MOS is not organic to an armor battalion.

OBSERVATION 39.0 System operation of the TACMASS, primarily related to operating the Main station and conduct of PMCS, was mostly performed by two civilians. Tasks they performed were primarily system uploading, system downloading, programing model parameters, supporting controllers, and limited trouble-shooting.

RECOMMENDATION 39.1 Assuming implementation of RECOMMENDATION 34.1, consideration should be given to reducing to one the number of civilian system operators. This person should have training in computer science and programing, and should also obtain system-specific training from IABG.

OBSERVATION 40.0 Based on observation of system components and their operation and use, the following are identified as probable PMCS tasks: a) daily check of keyboards (controls), b) daily check of monitors, to include standardizing adjustments, c) periodic cleaning of monitors and keyboards, d) check of computer ventilation systems, e) periodic cleaning of heads on terrain-loading and AAR-recording equipment, f) daily check of cabling in/around vehicle stations, g) daily check of air conditioning filters and drainage, and h) periodic check of vehicle station audio connectors.

SUMMARY FINDINGS: TACMASS TRAINING

This section addresses TACMASS as a training system and experience. The training involved approximately 4 hours of system operation instruction conducted by IABG and approximately 20 hours of tactical training using the TACMASS and conducted by the Controller/Trainer with coordination of the unit Commanding Officer. Information and data were obtained from six major sources or techniques: a) structured data collection forms (Observational Checklist) completed by SMEs, ARI, and Test Team members, b) debriefings of these evaluators (Observational Comments Report), c) evaluator ratings of training support (Tutorial Evaluation), d) ARI detailed assessment of training support (Programmed Introduction of Familiarization Evaluation), e) soldier evaluations (Operator Training Checklist), and f) soldier ratings (Assessment of TACMASS Training). Training on the TACMASS involved two phases: the first was system operation training and the second was tactical training (ARTEP-related). The Operator Training Checklist was administered at or near the end of each training phase. Hence, the first administration provided information on system training and the second administration yielded information more concentrated on tactical training. This report concentrates on the most important or potentially influential training deficiencies and findings. More exhaustive and detailed findings have been recorded in the Observational Comments Report, TACMASS Operator Training Assessment, Programmed Introduction for Familiarization (PIF) Evaluation, and TACMASS Observational Checklist Consensus Report of SMEs and Test Team Members. ARI was not officially requested by TCATA to specifically evaluate training; the CEP Resume Sheet of 1 Jul 86 indicated a personnel resource requirement from TRASANA (TRAC), presumably to evaluate the sufficiency of operator and student training programs.

Three areas of training are addressed in the findings: training support, training content and conduct, and training outcome. Training support includes training aids, equipment, and physical environment. Training content and conduct includes methodology and soldier evaluations. Training outcome includes ratings of usefulness, efficacy, and transferability.

Training Support: The physical environment in which the training was conducted is described in the Training Description section of this report. Other than system components used for demonstration (station controls) and the AAR equipment (controls, large screen monitor, and printouts), the only training aid used was an overhead projector. A "tutorial" computer program and single "manual" (computer printout) were available but not used in soldier training.

OBSERVATION 41.0 A formal Program of Instruction (POI) training package is needed.

RECOMMENDATION 41.1 A POI should be developed by TRAC, with coordination and validation by IBAG.

OBSERVATION 42.0 The Programmed Information for Familiarization (PIF) "tutorial" suffers from grammar (translation) errors, erroneous content, poor organization, and overly technical material.

RECOMMENDATION 42.1 The PIF, as presently configured, is not a tutorial and should not be used as such. It does, with revision and appreciable reduction of technical data, offer potential as a training tool to accomplish familiarization with system and station capabilities. Detailed comments (22) and suggestions for revision are available in the PIF Evaluation report.

OBSERVATION 43.0 The After Action Review (AAR) represents a potential training tool of appreciable value to TACMASS users. However, training benefits appear limited by AAR equipment configuration and the need to provide more emphasis and training of AAR use to system controllers.

RECOMMENDATION 43.1 TACMASS controller training should provide additional guidance and experience in the construction (flagging) of AAR reports and use of AAR capabilities. (See also OBSERVATION 8.0)

OBSERVATION 44.0 Controllers and users (particularly COs) have no manuals for TACMASS operation and use.

RECOMMENDATION 44.1 A nontechnical, ready-reference format, manual attending to basic operations, capabilities, limitations, and interactions of each unique station should be designed and made available prior to training of key personnel. This manual should include emphasis on training goals and examples and use of AARs.

OBSERVATION 45.0 Some training aids, primarily control consoles and overhead transparencies, were employed. However, the quantity and quality of transparencies should be improved. Also, the teaching opportunity allowed by AAR capabilities was not fully exploited.

RECOMMENDATION 45.1 More use should be made of overhead transparencies and the demonstration potentials of the large AAR screen in training soldiers (users). (See also OBSERVATION 2.0)

OBSERVATION 46.0 No formal evaluation or appraisal of user proficiency was conducted at the end of system training.

RECOMMENDATION 46.1 TACMASS user proficiency resides in a knowledge and skills base. The inability to identify and correct deficiencies can complicate and degrade the efficacy of tactical training which follows system training. Basic skills in operating controls appear readily assimilated through practice. However, knowledge decrements can have detrimental effects on performance and should be formally identified and remedied prior to beginning tactical training.

Training Content and Conduct: On an overall basis, the TACMASS training content was relevant, sequential, and adequate in establishing basic operational competencies in soldiers. Training conduct was generally adequate in length (approximately 4 hours) and format (approximately 1 to 3 ratio of lecture to exercise). The deficiencies noted below are intended to suggest improvements which could make both system and tactical training more efficient and effective.

OBSERVATION 47.0 An overview of system capabilities, with particular attention to controller stations, is needed by all users during training.

RECOMMENDATION 47.1 Soldier users could profit from understanding the capabilities and limitations of controller operations. This knowledge should facilitate improved responsive and anticipatory performance.

OBSERVATION 48.0 Operator and controller system training stressed station operation and capabilities without purposively addressing the goals of TACMASS training.

RECOMMENDATION 48.1 All training accomplished with the TACMASS should stress command and control collective skills training goals, with careful distinctions noted between these goals and individual skills training. The accomplishment of this recommendation would be enhanced through instituting RECOMMENDATION 43.1.

OBSERVATION 49.0 Visibility and LOS are highly important and consequential parameters of both the TACMASS and the real world, though in training were not as thoroughly taught as desirable.

RECOMMENDATION 49.1 The concept, display, use, manipulation, and consequences of visibility (purple areas on screen) should be emphasized and demonstrated in user training. Particular attention should also be given to visibility differences between Driver and Commander/Gunner displays within the same vehicle.

OBSERVATION 50.0 After dismounting infantry, manipulation of the squad or vehicle can cause either to lose display of the other. While this situation is real, it can cause confusion.

RECOMMENDATION 50.1 The reality of this condition should be noted in training with, perhaps, the suggestion that the Commander/Gunner record coordinates of the dismounted squad. (See also RECOMMENDATION 9.1)

OBSERVATION 51.0 A number of real world variables impacting on METT exist within the TACMASS but were either not played or were played with minimal training. This may have contributed to some user performance degradation and/or confusion.

RECOMMENDATION 51.1 Training should include discussion and demonstration of smoke, night operational conditions, weather, shading, and use of thermal sight capabilities. These are all existing capabilities of the system. Particular attention should be given to the recognition and consequences to vehicular movement of barriers, water, terrain/slope, wooded areas, and impassible terrain. (See also OBSERVATION 2.0, 13.0, 17.0, and 18.0)

OBSERVATION 52.0 During TACMASS system training for controllers and, particularly, for soldier users, no specific and definitive discussion of critical tasks as performance proficiencies occurred.

RECOMMENDATION 52.1 Critical tasks for each station should be specifically identified and explained during system training. Not only would this serve to guide the learner, it would help to identify desired outcomes and answer the question of what is expected of the soldier. (These tasks for each station are identified in the TACMASS Observational Checklist Consensus Report of SMEs and Test Team Members. See also OBSERVATION 47.0 and 48.0)

OBSERVATION 53.0 Of 119 usable returns of the second administration of the TACMASS Operator Training Checklist, 16 comments made by soldiers were related to improving TACMASS training: 5 suggested a need for more training time, 4 suggested a need to reduce training time, and 4 indicated a need for more precise information on controls, displays, kills, and engagements.

To bring specific focus to the TACMASS system training which was intended to teach soldiers how to operate their stations, the TACMASS Operator Training Checklist first administration was conducted at the conclusion of system training. A total of 140 usable returns was obtained. The results, which suggested some system training content areas possibly in need of strengthening, constituted initial impressions of the training (system) and were subject to revision based on subsequent exercises (tactical training). There was no formal proficiency or knowledge evaluation by the trainer (IABG).

OBSERVATION 54.0 Soldiers were asked, using a three point scale (yes, some, no), if they had an understanding of 18 points of information about TACMASS and its capabilities, displays, and response requirements. Points for which more than 30% of respondents reported less ("some" or "no") than optimal understanding are listed below.

a. Nature of threat potential: 41% = some, 4% = no

b. Essential capability of each station: 39% = some, 8% = no

c. Nature of display information: 36% = some, 4% = no

d. Concept and manipulation of visibility: 39% = some, 9% = no

e. Consequences of visibility: 34% = some, 6% = no

f. Meaning of color codes for terrain features: 31% = some, 6% = no

g. How weather, smoke, and shading is displayed: 47% = some, 9% = no

h. Communication networks: 27% = some, 5% = no

i. Capabilities of vehicle (armament): 31% = some, 3% = no

RECOMMENDATION 54.1 A number (b, d, e, f, g) of these perceived content deficiencies in system training have been previously noted by sources and techniques other than soldiers' evaluations. The results of the second administration of the TACMASS Operator Checklist toward the end of tactical training exercises indicated that some of these perceived informational decrements may have been resolved by experience. However, several remained less than optimally understood and should be addressed as system training content deficiencies.

a. Safety and handling concerns: 22% some, 8% no

b. Nature of threat potentials: 29% some, 5% no

c. Essential capability of each station: 24% some, 7% no

Training Outcome: Evaluations of TACMASS training experiences were obtained from three sources: a) soldier assessments of their knowledges and associated transfer value, b) SME evaluation of ARTEP task-related performance over iterations of TACMASS scenarios, and c) comparative ARTEP performances following TACMASS experiences. ARI was only involved with the soldier assessments source of information on training outcome. Based on the 119 usuable returns of the TACMASS Operator Training Checklist second administration, the following information emerged.

OBSERVATION 55.0 Soldiers were asked to identify the most difficult task to learn in operating their stations. Of 83 comments:

a. 11 identified operation of station controls (See also OBSERVATION 26.0);

b. 21 identified use of station displays--7 noted use of colors and 11 noted use of LOS/visibility (See also OBSERVATION 2.0 and 49.0);

c. 24 identified specific tasks--8 noted steering or driving of a vehicle, 6 noted movement or maneuvering, 4 noted acquisition of OPFOR, and 4 noted use of cover and concealment; and

d. 26 indicated that no tasks were difficult.

OBSERVATION 56.0 Soldiers were asked to identify the TACMASS task which they perceived to provide the best training value. Of 89 comments:

a. 22 identified maneuvers--8 noted vehicular maneuver and 8 noted use of terrain features;

b. 29 identified communications--10 noted command and control, 8 noted reporting, and 5 noted coordinating movement;

c. 22 identified tactics--9 noted engagement of the enemy, 4 noted use of cover and concealment, and 4 noted obtaining and using field of fire/vision; and

d. 13 indicated that no tasks provided training value.

OBSERVATION 57.0 Enlisted soldiers (Drivers and Commander/Gunners) were asked if <u>their</u> ARTEP performance would be improved as a result of TACMASS training and experience. Of 97 responses:

a. 41% indicated a definite or probable "yes";

b. 30% indicated a "maybe"; and

c. 29% indicated a definite or probable "no."

OBSERVATION 58.0 Officers (COs, XOs, and PLT LDRs) were asked if <u>their</u> ARTEP performance would be improved as a result of TACMASS training and experience. Of 20 responses:

a. 50% indicated a definite or probable "yes";

b. 20% indicated a "maybe"; and

c. 30% indicated a definite or probable "no."

OBSERVATION 59.0 Enlisted soldiers (Drivers and Commander/Gunners) were asked if their unit's ARTEP performance would be improved as a result of TACMASS training and experience. Of 97 responses:

a. 38% indicated a definite or probable "yes";

b. 41% indicated a "maybe"; and

c. 21% indicated a definite or probable "no."

OBSERVATION 60.0 Officers (COs, XOs, and PLT LDRs) were asked if their unit's ARTEP performance would be improved as a result of TACMASS training and experience. Of 20 responses:

a. 35% indicated a definite or probable "yes";

b. 30% indicated a "maybe"; and

c. 35% indicated a definite or probable "no."

OBSERVATION 61.0 Enlisted soldiers (Drivers and Commander/Gunners) were asked if their TACMASS station tasks and requirements directly related to their "real world" job. Of 97 responses:

a. 35% indicated "yes";

b. 38% indicated "some"; and

c. 27% indicated "no."

OBSERVATION 62.0 Officers (COs, XOs, and PLT LDRs) were asked if their TACMASS station tasks and requirements directly related to their "real world" job. Of 19 responses:

a. 37% indicated "yes";

b. 53% indicated "some"; and

c. 11% indicated "no."

OBSERVATION 63.0 Enlisted soldiers (Drivers and Commander/Gunners) were asked if the TACMASS experience is or will be useful to soldier proficiencies. Of 98 responses:

a. 37% indicated "yes";

b. 45% indicated "some"; and

c. 18% indicated "no."

O SERVATION 64.0 Officers (COs, XOs, and PLT LDRs) were asked if the TACMASS experience is or will be useful to soldier proficiencies. Of 20 responses:

a. 40% indicated "yes";

b. 45% indicated "some"; and

c. 15% indicated "no."

OBSERVATION 65.0 The responses on the TACMASS Observational Checklist by SMEs, ARI, and Test Team members indicted that the following tasks or operations trained on the TACMASS might produce negative transfer:

a. Use of overhead (6400m) view vs map reading;

b. Determination of firing vehicle by a blinking vehicle symbol vs muzzle flash and/or dust; and

c. Trafficability of terrain (water, trees, steep slopes, etc.) without consequence vs "real world" considerations.

OBSERVATION 66.0 The responses on the TACMASS Observational Checklist by SMEs, ARI, and Test Team members indicted that the following tasks or operations trained on the TACMASS might produce positive transfer:

a. Command and control efforts and use of communications nets;

b. Use and appreciation of terrain features; and

c. Unit tactics, formations, and maneuvering.

OBSERVATION 67.0 As indicants of training outcomes, soldiers were asked following system training if they had a good "feel" for the functions and capabilities and a good knowledge of critical tasks of their stations. Points for which more than 30% of soldiers perceived less ("some" or "no") than optimal proficiencies are listed below.

a. Good feel for functions of station: 34% = some, 0% = no

b. Good knowledge of critial tasks of station: 37% = some, 2% = no

c. Good feel for capabilities of station: 41% = some, 6% = no

RECOMMENDATION 67.1 The second administration of the TACMASS Operator Checklist toward the end of tactical training exercises appeared to indicate that most perceived decrements were resolved by experience. However, one remained and should be addressed as a deficiency in training outcome.

a. Good feel for capabilities of station: 30% = some, 5% = no

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The following are offered as the most salient findings and suggestions emerging from the MANPRINT evaluation of the TACMASS. The efficacy of TACMASS training experience transfer to ARTEP performance was an issue for which TCATA assumed data collection, analysis, and reporting responsibilities and is not reported herein.

- Station controls appear adequate in design, configuration, and operation. Drivers' controls could be consolidated and/or made more realistic.

- Station displays, as hardware, are adequate. The adjustment of displays to standardize color quality (hue, saturation, brightness, contrast) is an important and recurrent need. Displays should be on swivel bases. Drivers should have a horizontal view option.

- The physical environment in which the TACMASS is trained and used needs to have uniform lighting for all stations, with due concern for map reading and for screen glare.

- Potential safety hazards involving open rack doors on computers, open electrical outlets on station control modules, and partition legs need to be corrected. All sources of possible hazards need to be appropriately labeled and definitively covered in training.

- The TACMASS software should be revised to include, at minimum: a) vehicle IDs in display; b) realistic movement rules for OPFOR; 3) refuel, rearm, and repair capabilities for vehicles; d) more realistic graphics such as vehicles, trees, and bridges; e) improved communications and more realistic consequences for the fire or mobility kill condition; f) weapons effect on structures and obstacles; and g) reduced computer processing time for commands.

- After Action Review capabilities, as a major training tool/opportunity, are degraded by configuration of equipment and insufficient training in their use.

- Controller stations should be housed in a single and isolated cubicle to enhance communication and efficiency. The Threat and Fire Support positions should be provided light pens to enhance operational efficiency.

- Training support aids should be developed and validated. These aids include: a) improved visuals; b) nontechnical user manuals; c) revised "tutorial"; d) increased use of AAR display in system training; and e) legends for color codes, symbology, and information displays posted in stations.

- Training time for system operation appeared adequate for users and controllers.

- Training content for system operation was perceived by soldiers as having areas of insufficient information. Most of these "deficiencies" appeared resolved by the end of tactical training, though the use of tactical training time to resolve perceived deficits in system training potentially degrades the efficacy and outcome of tactical training. Areas/subjects which may need more thorough attention include: a) overview of system capabilities; b) training goals; c) visibility; d) movement impediments; e) station capabilities and critical tasks; f) nature and operation of threat; g) color codes; and h) smoke, shading, and weather.

- Personnel necessary to operate controller stations are generally available to armor and mechanized infantry battalions. It is possible that a single civilian, trained in computer science (programing and hardware) with supplementary training by IABG, could satisfy system operator requirements. Other than PMCS, system maintenance likely should be contracted to IABG: as the designer, developer, and manufacturer of the TACMASS, IABG has a unique knowledge of this complex system.

- Approximately 30% of soldiers (officers and enlisted) doubted that individual or unit ARTEP performance would be improved as a result of TACMASS experiences. Approximately 15% of soldiers doubted that TACMASS experiences were useful to soldier proficiencies.

- Soldiers (users) and evaluators (SMEs, Test Team members, ARI) identified maneuvering (including use of terrain), communications (including command and control and reporting), and tactics as experiences providing the best training value. These findings support the intended training goals of the TACMASS.